The ATLAS and CMS Detectors at the Large Hadron Collider

Two large international collaborations of scientists, of whom about 20 percent are U.S. physicists, are building the ATLAS (A Toroidal LHC Apparatus) and CMS (Compact Muon Solenoid) detectors, the major particle detectors that will operate at the Large Hadron Collider at CERN. These two collaborations share a common goal—to explore the mysteries that underlie the basic building blocks of matter and the forces acting on them.

The two detectors will occupy different locations on the circumference of the 16-mile accelerator ring. At the center of each detector, beams of high-energy protons from the LHC will collide head on, creating about a billion proton-proton collisions each second. The detectors will measure the energies, directions, and identities of the particles that fly off from each of these collisions. Computers will process the resulting information fast enough to select and record only the one in ten million collisions that might carry the seeds of a new discovery.

Although the detectors will be the size of five-story buildings, each one will have sensors capable of measuring particle trajectories to better than a thousandth of an inch, along with other devices that can precisely measure the amounts of energy carried by collision products flying off in every possible direction. Each detector will have large superconducting magnets to deflect electrically-charged collision products and devices to measure their curving tracks. The detectors will be designed to withstand the intense radiation environment at the center of particle collisions for many years.

More than 500 scientists from 60-plus U.S. universities and six national laboratories (about 20 percent of the collaborators) are participating in the construction of ATLAS and CMS, and their eventual application to exploring the energy frontier at the LHC. They are making major contributions to almost all of the subsystems of these detectors. The ATLAS and CMS collaborations will carry on a long tradition of international collaboration on particle detectors. For example, the Europeans, the Japanese, the Russians and many others are partners in detectors at U.S. accelerators.

Why Two Detectors?

The ATLAS and CMS detector collaborations have much the same physics goals, but their detectors, although equally complex, are quite different. The extraordinary challenge of reliably decoding nature's secrets with high energy particle experiments demands sophisticated instruments. It is important to confirm the signals obtained from one detector with information obtained independently with another.

To assure independence of information, the ATLAS and CMS detectors differ substantially in their details: different configurations of magnets, for example, as well as different particle identification strategies, and different technologies for the energy-measuring devices and for the sensors that measure particle trajectories. Each detector puts somewhat different emphasis on its various subsystems, so that each may do some things better than the other. In the end, if different experimenters working with different instruments arrive at the same understanding of nature, that understanding is very likely to be correct.

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